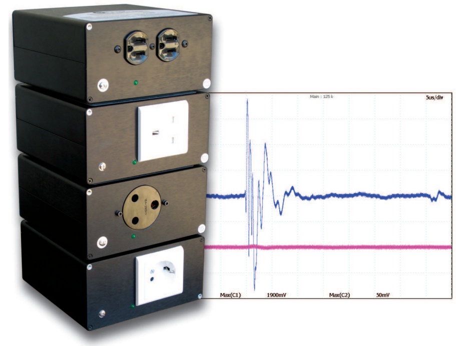
OnFILTER Advantage



Electrical noise (EMI) on power lines and ground interferes with normal operation of equipment and may lead to equipment and component damage. EMI is a significant problem in today's environment.

EMI generated by equipment must confirm to CE, FCC and other regulations. No equipment may be sold unless it complies with these regulations' requirements. Why then would a piece of equipment in full compliance with emission standards cause problems in real-life applications? And why would a piece of equipment that behaved so well in EMI immunity tests react so poorly to electrical distrubances on the factory floor?

There is a number of reasons for that - some have to do with the equipment itself and some are caused by issues related to installation. Either way, the problem of managing EMI in power lines ultimately rests with the end-user.

Lets review most critical issues that are at the heart of these problems.

Equipment and EMI

A fully-compliant piece of equipment can be a significant EMI pollutant at the factory. Origins of that lay in big discrepancy between EMC regulatory requirements and real-life applications. Below are just two most significant ones.

Transient Signals

To start with, most of power-line noise is transient signals, i.e. spikes generated by relays, solenoids, stepper motors, switching power supplies and so on. It is also the transient signals that constitue most of the EMI problems.

The problem is that EMC regulations specify very slow quasi-peak detector for emission compliance test. This detector is geared towards continuous signals and it has very slow reaction time. The end result is that very strong transient signals may produce very little of signal at the output of such detector, sometimes up to 43.5dB (~150 tumes) less than the peak of the transient signal making equipment "compliant." Figure 1 shows how a strong transient signal generates the same level at the output of the quasi-peak detector as a much-weaker continuous signal. The result of using quasi-peak detector is that equipment manufacturer has no motivation to reduce transient signals and an unsuspected user of this equipment has no idea about actual EMI noise that this equipment will bring to his environment.

OnFILTER uses a different approach to reducing noise. We put our main focus on reduction of signals present in the actual environment, not just on meeting compliance requirements. Figure 2 shows typical performance of an OnFILTER model with the transient noise signal on power line. As seen, in this case the filter attenuated the transient signal on actual power line by 23 dB.

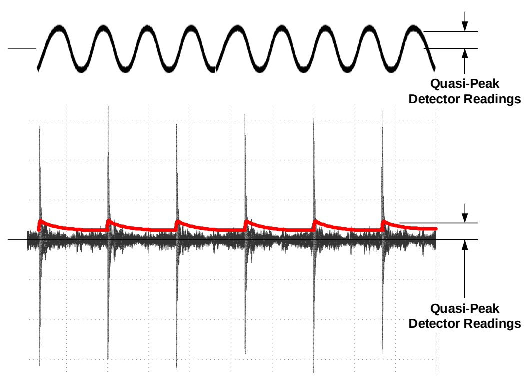


Figure 1. Quasi-peak detector performance with continuous and transient signals

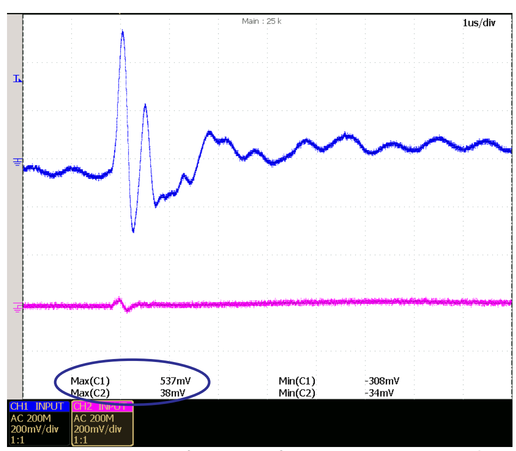


Figure 2. Typical performance of OnFILTER CleanSweep® filter. Upper trace - raw noise, bottom trace - after the filter.

Power Lines and Line Impedance for EMC Test

Since EMC regulations is the main, if not the only motivation for reducing of EMI for equipment manufactuer, any "imperfection" in the regulations causes significant problems in the field. For conducted emission EMC regulations specify a patricular artificial power line simulator (LISN) with 50 Ohms termination typically used in high-frequency equipment - something that a real power line is not likely to ever have. As a result, EMI power line filters that are built into equipment to deal with noise are optimized for such artificial environment, but perform rather poorly in more practical situations. Filter manufacturers who are more attuned to the real-life applications provide specification of their filters in the environment more reflective of real aplications, such as 0.1/100 (curve C), where impedance of power line is more realistic 0.1 Ohm (impedance of load, i.e. of your equipment, can vary greatly - for simplicity 100 Ohms corresponding to 144W at 120VAC or 625W at 250VAC is used).

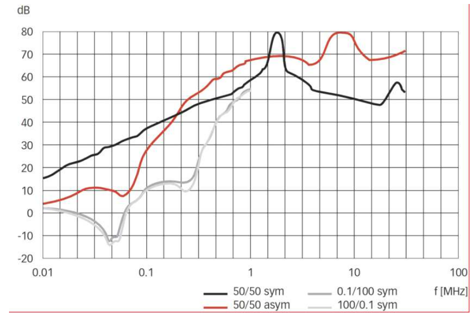
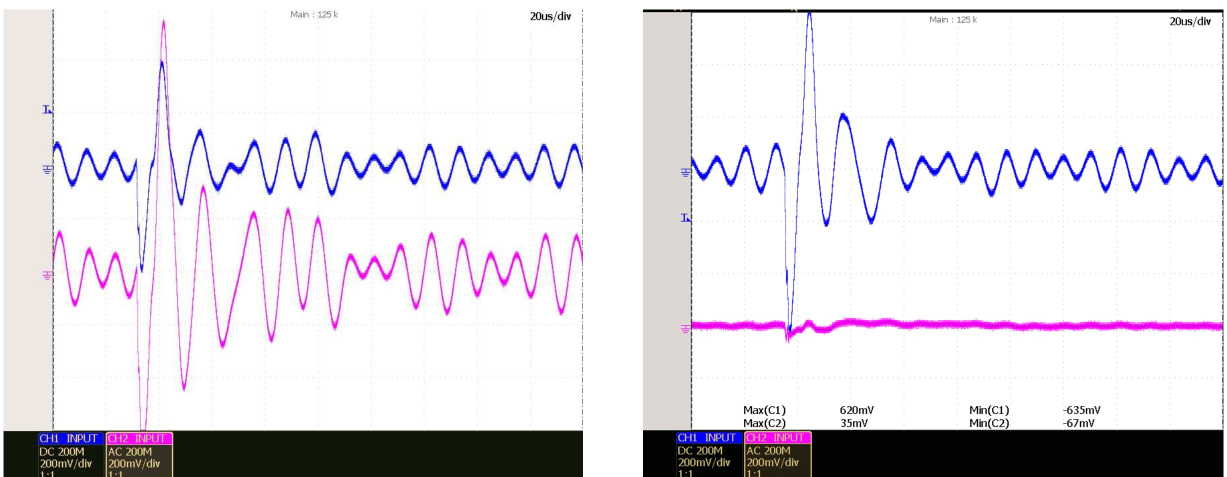


Figure 3. Frequency response of a typical off-the-shelf EMI power line filter. Curves A and B are for 50 Ohms termination (differential and common-mode); curves C and D are for 0.1/100 and 100/0.1 Ohms termination.

Figure 3 shows typical frequency response of an off-the-shelf power line EMI filter (its manufacturer will remain unnamed since such performance is typical for conventional filters). As seen, it has reasonable signal attenuation at higher frequencies, but only with 50 Ohms termination – meaning that in actual use where output impedance of power line is extremely low and the load impedance is only accidentally may be 50 Ohms, this filter will actually amplify the noise as seen in curve C - negative attenuation is amplification. Figure 4 shows just that.



a) Regular EMI Filter

b) CleanSweep® OnFILTER EMI Filter

Figure 4. Power line noise with a regular EMI filter (a) and with a typical OnFILTER model (b)
Top (blue) trace is the "raw" noise on power line; bottom (red) trace is the signal after the filter.

The screenshot on the left (Figure 4a) shows performance of a typical off-the-shelf EMI filter on a power line. Upper (blue) trace is the original noise on power line, lower (red) trace is the signal at the output of this filter. As seen, this filter actually amplifies the signal is was trusted with suppressing, which correlates with the filter's own specification of Fig. 3. The right screeenshot in Fig. 4b shows performance of an OnFILTER' typical CleanSweep® model. The arrangement of traces on the screen is the same as in Fig. 4a. As seen, the noise after the filter is suppressed to the level of practical insignificance.

The two examples above show how a piece of equipment fully compliant with all emission standards can still put plenty of undesirable electric noise into your power and ground network.

There are factors, however, that can substantially affect noise on power lines which depend on the factory installation, not necessarily on equipment itself.

Effect of Equipment Installation on EMI

The biggest effects on EMI in a factory environment is an elaborate network of long cables for power and ground.

Long Power Lines and Distributed Inductance and Capacitance

What happens when a piece of equipment is installed in a factory or in a similar environment? It is connected to an already-existing very complex power line and ground network in your facility. Cables may be excessively long and, in addition, coiled. How does this affect the noise?

When equipment is installed in a production environment, long power and ground cables that are not normally present during the EMC test may significantly alter the nature of the noise. Long cables offer distributed inductance and capacitance between the wires and between the wires and ground; skin affect adds to loss of signal at high frequencies.

Figure 5 shows the transformation of a typical short transient signal generated by equipment as it propagates through the power lines. Parasitic inductance and capacitance of cable present a resonance tank which makes short pulses "ring" with the frequency that wasn't present in the original signal. A short pulse/wide bandwidth original signal is then transformed into a very different signal ringing at a relatively low frequency. This presents challenges for conventional filters since they operate better at higher frequencies and are ineffective at lower end of the spectrum where most of harmful signals on power lines reside.

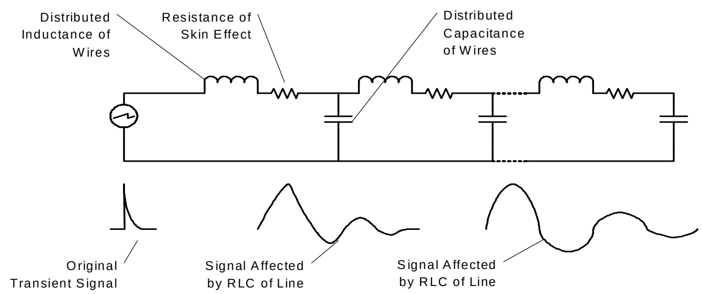


Figure 5. Pulse Transformation on Long Lines

These "secondary" signals were not present during compliance test simply because in a test laboratory the setup was highly-controlled and the power and other cables were quite short. As a result, typical EMI filters of Figure 3 has reasonably good performance at high frequencies, but very poor one at low frequencies, but this is where most of noise on power lines and ground resides. Curves C and D in Figure 3 stop at 1MHz. In all fairness, there isn't much an equipment manufacturer can do to reduce influence of the power and ground cables besides reducing overall emitted noise. The task of managing this type of EMI rests with the equipment user.

Power Lines and Ground as a Network

Power lines and ground form a very complex and intricate network in your facility, somewhat similar to blood vessels in a human body. Thick trunks/wide arteries deliver power to key junctions; from there smaller cables/blood vessels proceed to reach smaller junction with fuse boxes; and from there regular cables/capillaries get the energy to the equipment/organs. In such complex network anything affects everything. Unlike radiated EMI that propagates through the air, effects of conducted EMI are not as quickly diminished with the distance; and the shielding doesn't affect noise on lines either.

As was described above, the longer the wires, the more is the proportional share of lower-end frequencies of the spectrum, often extending down to tens of kilohertz. The typical off-the-shelf filters don't work well at low frequencies. For comparison, Figure 6 which shows typical frequency response of an OnFILTER power line filter in 0.1/100 Ohms environment most closely resembling actual power lines. As seen, at low frequencies it offers up to 50dB attenuation - compare it with the performance of an off-the shelf EMI filter for the same impedance setting.

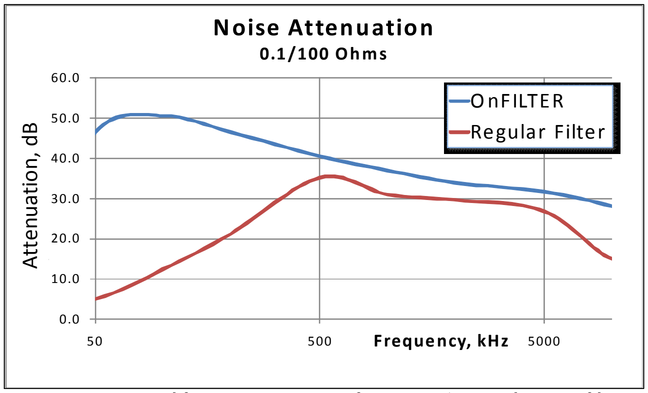


Figure 6. Typical frequency response of OnFILTER' power line EMI filter and of a regular EMC filter (0.1/100 Ohms)

This is how an EMC-compliant equipment can be a "gross polluter" when installed in your environment.

Transient Voltage Suppression

OnFILTER' CleanSweep® EMI filters perform another important function - effective suppression of strong transient voltage spikes. Regular transient voltage suppressors (TVS) and similar devices clamp voltage when it significantly exceeds peak volttage of normal power line signal (for 250V it would be 353V). However, many strong spikes happen not necessarily at the peak of the waveforms as shown in Figire 7. OnFILTER' CleanSweep® EMI filters treat such transients as EMI and supress them regardless where these spikes occur on the waveform. This still doesn't preclude use of TVS - CleanSweep® EMI filters augment them to reduce transients where TVS can't.

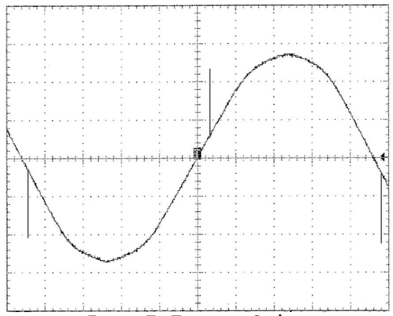


Figure 7. Transient Spikesr

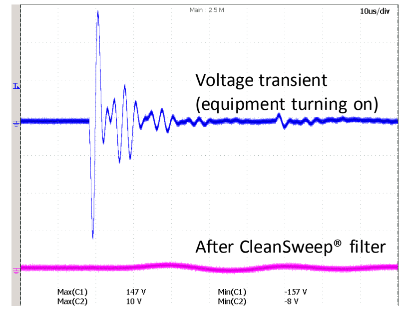


Figure 8. Suppression of Transient Spikes by CleanSweep® EMI Filter

OnFILTER: Superior EMI Suppression In Real-Life Applications

The users of electronic equipment until now didn't have many options to manage EMI in their environment. Even fully-compliant equipment can be a source of significant noise; and when connected to your power line and ground network, this noise gets new properties and propagates throughout the facility, causing equipment malfunction and possible EOS (Electrical Over-Stress) to sensitive components.

OnFILTER empowers you to resolve your EMI problems right at your facility without the need to redo the power line and ground routing and without difficult changes inside the tools. OnFILTER' EMI suppression filters plug between the wall outlet and your equipment providing it with noise-free power for operation without power-line EMI influence. Filters require no maintenance and are easy to install as shown in Figure 9. CleanSweep® filters attenuate noise in both directions.

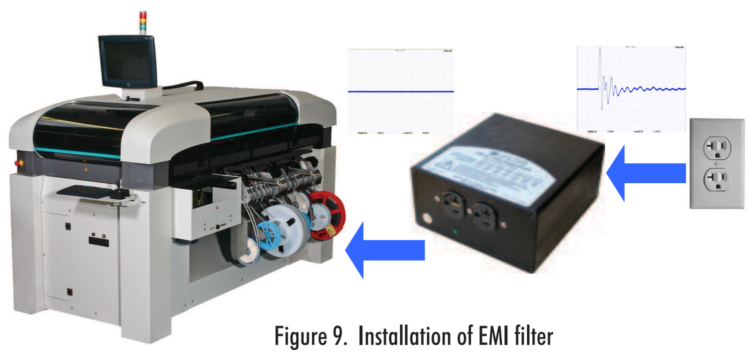


Figure 9. Installation of EMI filter

Once you bought and installed an EMC-compliant equipment in your facility, there isn't much you can do to the equipment itself in order to reduce its emission or to reduce its sensitivity to EMI on power lines and ground. We didn't limit ourselves by EMC regulations, but addressed the problems of EMI in actual use environnment. Our filters are designed for reduction of noise of all types of waveforms.

Overall, OnFILTER products provide the best value in the industry for managing EMI environment in industrial and in many similar aplications.

OnFILTER manufactures variety of EMI filters for power lines - single phase 120 and 250V; three phase Delta and Wye with many permutations. Contact OnFILTER with any questions you may have. If you have some unique requirements, we may be able to help.

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